Filters are tone knobs

The bass and treble knobs on a car stereo don't add any new notes to the music; they turn some frequencies up and others down. A **filter** does the same thing to a signal. It takes the signal's recipe of sines and turns each entry up or down, and it also delays each one a little. The report card for a filter is its **Bode plot**, which is the most-used graph in analog design.

A circuit as a frequency machine

A Bode plot shows two things, both plotted against frequency:

- **Magnitude**: how much of the signal comes out, $|H(f)|$, usually in dB
- **Phase**: how late it arrives, $\angle H(f)$, in degrees

The RC low-pass

A resistor R and a capacitor C in the classic low-pass arrangement let slow signals through and turn fast ones down, so together they act like a treble-cut knob. It's the first filter everyone builds, and its cutoff frequency is

$$f_c = \frac{1}{2\pi RC}$$

You don't need calculus here, because the course doesn't derive its magnitude and phase; take the two formulas below as given for now. They describe what you would measure if you swept the filter through frequencies one at a time:

$$|H(f)| = \frac{1}{\sqrt{1 + (f/f_c)^2}} \qquad \angle H(f) = -\arctan(f/f_c)$$

At $f = f_c$ the magnitude is $|H| = 1/\sqrt{2}$ (−3 dB) and the phase is −45°. With $R = 1\,\text{k}\Omega$ and $C = 100\,\text{nF}$, for example, $f_c \approx 1592$ Hz.

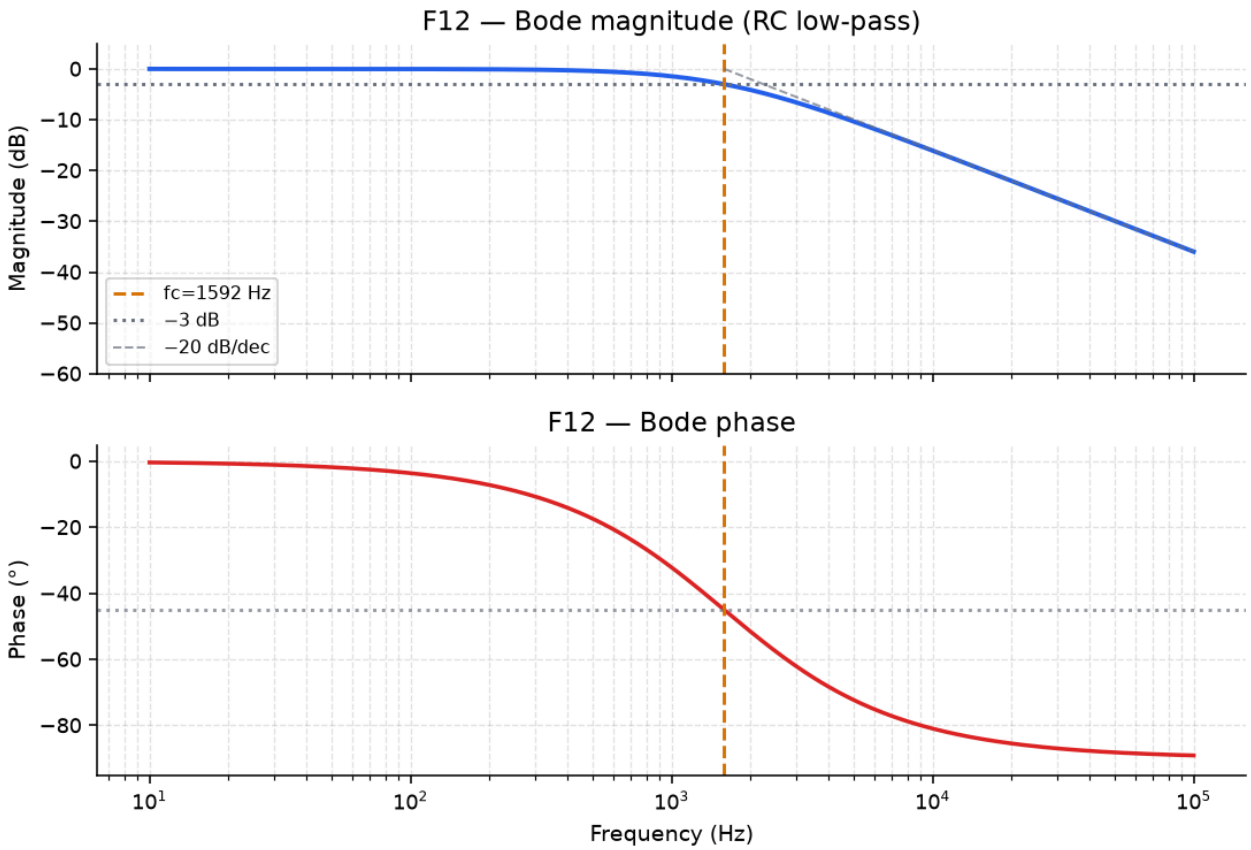


Figure 1: F12 — Bode explorer

Only the product RC matters, so if you double R and halve C, f_c stays where it is, like two different amp settings that happen to land on the same tone.

In Lab 04, Part 1, you'll move R and C on the F12 explorer, and then draw this Bode plot from the two formulas in a script of your own.

Next: Reading a Bode plot